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Role of AI and Drones in Monitoring Wheat Fields

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Wheat (*Triticum spp.*) belongs to the Poaceae (Gramineae) family originally from the Near East and Ethopian Highlands, but now cultivated worldwide. Mainly there are three species of wheat namely, *Triticum aestivum* (bread wheat), *Triticum durum* (macaroni wheat) and *Triticum dicoccum* (Emmer or Khapli wheat) which are generally grown on commercial basis in the Indian subcontinent from pre-historic times with share of production in percent 95%, 4% and 1% respectively (khan *et al*, 2010).

Wheat (*Triticum aestivum L.*) constitutes one of the main grains that accounts for culinary consumption by offering fifty percent of protein needed and over fifty percent of caloric energy for the Indian citizens. There-fore, continuous research is being made to produce higher yields to feed the nation (khan *et al*, 2015). India cultivated wheat on 33.61 million hectares yielding 106.21 metric tons and had an average of 3160 kilograms per hectare in 2019-20 (Anonymous, 2020).

Wheat (Triticum aestivum L.) has a central role in world food security, as it represents more than 1/4th of the global total grain production, which serves as a major source of staple food for over 1/5th of the human population worldwide (FAO,2023). Wheat is arguably the most important food crop in the world. World wheat production currently stands at about 550 million metric tons (MMT) (International Wheat Council, 1994). Of this, about 100 MMT is traded each year on the international market (Morris *et al*, 1996). The cultivated area under wheat in India has shown an increasing trend, from 29.04 million hectares to 30.54 million hectares with a magnitude of 1.5 million hectares (5%) net gain in terms of area. Uttar Pradesh has largest share in area with 9.75 million hectare (32%), followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%) and Bihar (6.82%). However, a major expansion in wheat area was observed in the states such as Jharkhand (51%), Madhya Pradesh (27%) and Rajasthan (13%) (Ramadas *et al*, 2020).

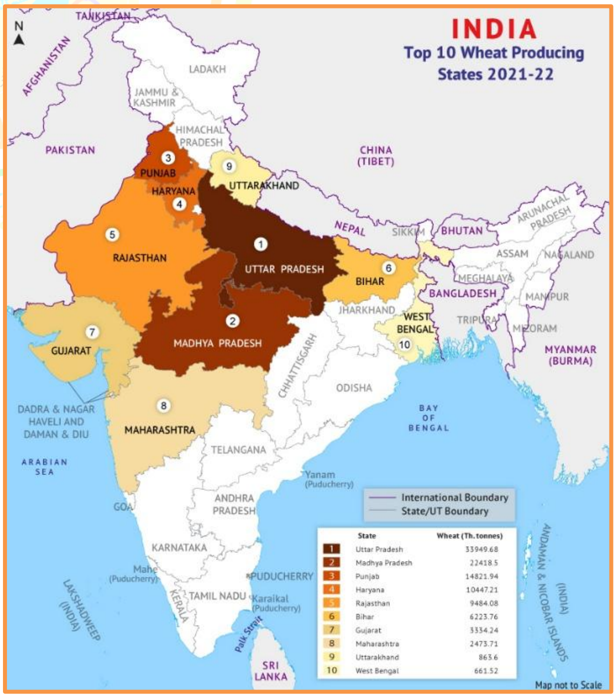


Fig 1.: Wheat Production in India (India Ministry of Agriculture, Directorate of Economics and Statistics, 2021-2022) Source :- *Mapsofindia.com*

What is Artificial Intelligence (AI)?

An interdisciplinary field of study called artificial intelligence aims to replicate human intelligence in robots that resemble human cognition and behaviours, including learning and problem-solving. Research scientists and extension specialists are now using AI technology to address problems in agriculture productivity. AI technology can help farmers increase yields by assisting them in choosing suitable crop types, adopting improved soil and nutrient management practices, managing pests and diseases, estimating crop production, and forecast commodity prices (Liu, 2022). AI uses deep learning, robots, the Internet of Things, image processing, artificial neural networks, wireless sensor networks (WSN), machine learning, and other cutting-edge methods to tackle agricultural challenges. These AI technologies can now assist farmers in real-time monitoring of several items obtained from their farms, such as weather, temperature, water usage, or soil conditions, to inform their decisions better. AI is used to develop smart farming practices that reduce farmers' losses while providing them with high yields (Ayed & Hanana, 2021). The foundation of AI is the assumption that human intellect can be described in a way that makes it simple for a computer to duplicate and carry out activities of all sizes. Learning, reasoning, and perception are all goals of AI. AI is having a significant impact across the board. Every industry is looking to use intelligent machinery to automate specific jobs (Sharma *et al*, 2022). It occurs when human intelligence is defined so that a machine can comprehend it. Furthermore, AI technology in agriculture has the potential to improve the world. This technology can perform tasks ranging from simple to complex. The goal of a machine is to learn, reason, and perceive. It aids in the automation of jobs in a variety of industries. The use of intelligence machinery simplifies a variety of tasks (Bolandnazar *et al*, 2020).

Need for AI in agriculture

Agriculture is a labour-intensive occupation, and with rising population and agricultural production demand, automation is becoming increasingly important. AI significantly assists farmers in components, technologies, and applications. Predictive analytics and improved farm and crop management systems guarantee crop quality and supply (Vijaykumar & Balakrishna, 2021). Through satellite photos and meteorological information, businesses determine acreage and track crop health in real-time. Businesses can use big data, AI, and ML technologies to anticipate pricing, calculate tomato output and yield and identify pest and disease infestations (Subeesh & Mehta, 2021). They can advise farmers on demand levels, crop varieties to plant for the best profit, the usage of pesticides, and future pricing patterns. AI will be a potent instrument that can help organisations deal with the growing complexity of contemporary agriculture since it dramatically reduces the shortage of resources and labour. It is past time for large corporations to invest in this area. Many industries use AI technology to boost productivity and efficiency (Awasthi, 2020). AI technologies are helping people in every sector overcome conventional obstacles. Finance, transportation, healthcare, and agriculture are among the sectors that employ AI applications (Skvortsav,2020).

Agriculture parameters monitored by artificial intelligence

Artificial Intelligence (AI) is increasingly used in wheat cultivation to monitor and manage key agricultural parameters with high precision. One of the main areas of focus is crop health monitoring, where AI analyzes aerial images and sensor data to detect signs of nutrient deficiencies, pest infestations, and fungal diseases such as rust or blight. AI systems also assess soil conditions, including moisture content, nutrient levels, and pH, which are critical for healthy wheat growth (Shadrin *et al*, 2014). Through image analysis and machine learning models, AI tracks growth stages of the wheat crop from germination to heading and grain filling enabling more accurate yield predictions. It also identifies weed presence and distinguishes them from wheat plants, allowing for targeted herbicide application. Irrigation management is optimized by AI through the analysis of weather data and soil moisture levels, ensuring water is applied efficiently and only where needed (Mary *et al*, 2022). Additionally, AI assists in determining harvest readiness by analyzing crop maturity and environmental factors. By monitoring these parameters, AI not only improves productivity and sustainability in wheat farming but also reduces input costs and enhances decision-making for farmers (Gambhire & Mohammad, 2020). Some Agriculture parameters monitored by AI are shown in Fig. 2.

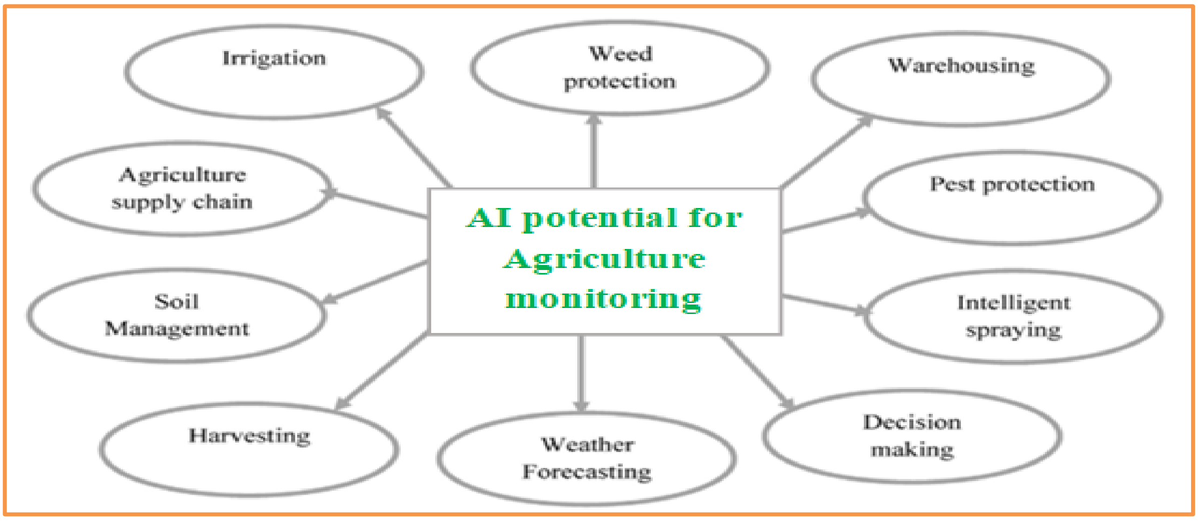


Fig. 2: Agriculture parameters monitored by AI

Applications of drone in agriculture

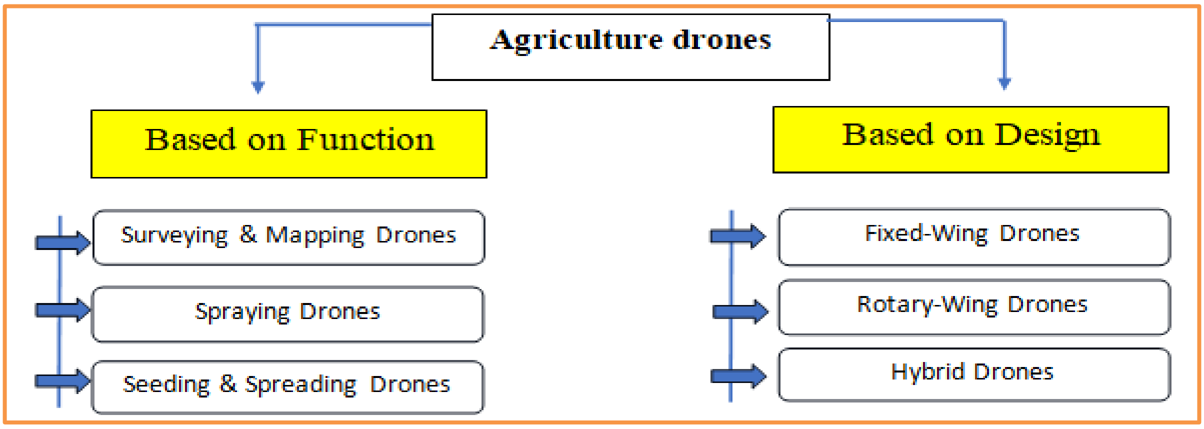
Fig. 3 Agriculture drone is being used in the wheat field (Singh et al. 2024)

"Drones are revolutionizing agriculture with their ability to gather vast amounts of data quickly and efficiently. Here's how drones are being applied in modern agriculture. Use of drones can be advantageous in the case of pesticide spraying, replacing labour intensive and hazardous conventional methods particularly in difficult areas such as hills. Artificial intelligence and machine learning can be combined with NDVI (Normalised Difference Vegetation Index) imaging technology-based high-resolution images captured by drones to develop understanding of soil conditions, plant health and crop yield prediction. Every individual plant can be located separately and analyzed using image processing algorithms, if it is stressed" (Chen & Kuo, 2022). Using this result, farmers can take preventive action to cease the spread of diseases to other crops. Timely actions can be taken to prevent losses from biotic stresses such as insect pests and diseases, optimize fertilization, rationalize irrigation and reduce the impact of climate change and unpredictable weather using analyzed insights from data collected by drones and satellite-based remote sensing (Noor & Noel, 2023).

Drone technology uses tiny sensors (such as pressure, magnetometer, gyros, and accelerometers) whose sizes are getting smaller every day and whose performance is always improving" (Barkunan *et al*, 2019). "Furthermore, drone technology is advancing due to the ongoing development of strong CPUs, GPS modules, and increased digital radio range. UAVs may now be smaller and carry more cargo because to advancements in embedded systems and motor technology. These further results in improved drone control for monitoring distant fields (Wang *et al*, 2006).

Types of agriculture drones

Agricultural drones are increasingly used to enhance productivity and efficiency in farming. They are generally categorized based on their function and design. Here are the main types of agriculture drones:



Advantages of Drone Usage in Farming: Efficiency, Cost, and Sustainability

Drone technology is pervasively affecting many aspects of farming practices which are following here (FSSI, 2023).

- **Increase in productivity** – Drone use by farmers will increase productivity by decreasing labor usage. This is because they can decrease manual surveillance or eliminate it altogether.
- **Crop monitoring** – Farmers now have the choice to continuously monitor their crops and conduct surveillance from the comfort of their homes.
- **Locust control** – Locusts are an agricultural menace and can devastate crops overnight. Using drones, locusts can be sprayed with insecticides without harming crops and livestock too.
- **Crop protection** – Drones can be used to spray right amount of pesticides at the appropriate time, resulting less wastage and greater output.
- **Crop plantation** – Drones can also be used in the early stages of the agricultural growing cycle, like mass sowing and planting in less time.
- **Managing Water Reserves** – Farmers use water to grow crops. Managing the water is vital for effective crop growth. Drones, when used to water crops with drip irrigation practices, are a great way to be water-efficient.

Conclusion

Wheat stands as one of the most important food grains worldwide, and it holds particular importance in India's farming landscape by contributing to both dietary needs and national food availability. Technologies based on AI are transforming wheat farming by allowing farmers to closely track the condition of the soil, the growth of the crop, the presence of pests, and the need for water, all of which support better results and responsible resource use. Likewise, drones give farmers the ability to gather detailed field information quickly and carry out tasks such as spraying and planting more efficiently, saving time and effort. These tools work together to give farmers the insights they need to make smart choices, lowering costs and increasing crop output. To sum up, the combined use of AI and drone technology is setting the stage for a new era in farming. Adopting these tools will enable India and other wheat-producing countries to satisfy increasing food needs, protect the environment, and adapt better to the evolving challenges of agriculture.

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